

***Frankliniella invasor*, new species, and notes on *F. gardeniae* and the *Frankliniella* spp. in Hawaii**
(Thysanoptera: Thripidae)

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None of the 7 spp. of *Frankliniella* now known in Hawaii is indigenous. They all arrived here sometime in the 1920's and thereafter. They were all well-known species prior to their arrival, but one of the recent arrivals happened to be undescribed, and the name of *invasor* is hereby given. The origin of this species must be in the Caribbean-Central American region where this group of *Frankliniella* has richly evolved. A search through the collections in the U. S. National Museum (USNM) and California Academy of Sciences (CAS) has revealed a few obscure and unnamed specimens of *invasor* from Puerto Rico. However, nothing is known as to how the species had been transported to Hawaii. A redescription of *F. gardeniae*, an allied species, is provided, and field observation notes on the *Frankliniella* spp. in Hawaii and a key to them are appended.

Grateful acknowledgements are made to Kellie O'Neill who provided advice and help for determining the species and allowed the search of the USNM Collection; and also to Paul H. Arnaud, CAS, who allowed visits to and loans from the Moulton Collection.

***Frankliniella invasor* Sakimura, new species (Fig. 1-5)**

Diagnosis: Belongs to the *tritici* group. Yellow body with cutaneous gray shading on abdomen in ♀ but without in ♂, major setae dark grayish brown and ocellar crescent brownish. Antenna V yellow between dark grayish brown IV and VI, II gray-washed in ♀ but pale in ♂; II elongate, cylindrical without subbasal constriction, 2.0-2.3 times as long as wide in ♀, 2.5-2.7 times in ♂, slightly produced anterodorsally, with 2 long setae at apex; III pedicel saucer-type, elaborately modified. All major pronotal setae nearly subequal to each other, about 1/2 pronotal length, 4 minor setae between 2 anteromarginal setae; in ♀ all major caudal setae nearly subequal to each other; in ♂ IXi short and dorsal seta i very long. Tergal comb on VIII short, complete or sometimes interrupted in ♀, practically absent in ♂.

♀ (*Holotype*): Yellow body with rich orange-yellow hypodermal pigments, weak grayish-brown cutaneous shading in band along foremargin of tergites I-VIII, often broader mesally, indiscernible in teneral specimens, labium not shaded at all; antenna I pale; II-V yellow, grayish brown-wash on distal 3/4 of II, distal 1/3 of III, distal 3/4 of IV (as dark as VI),

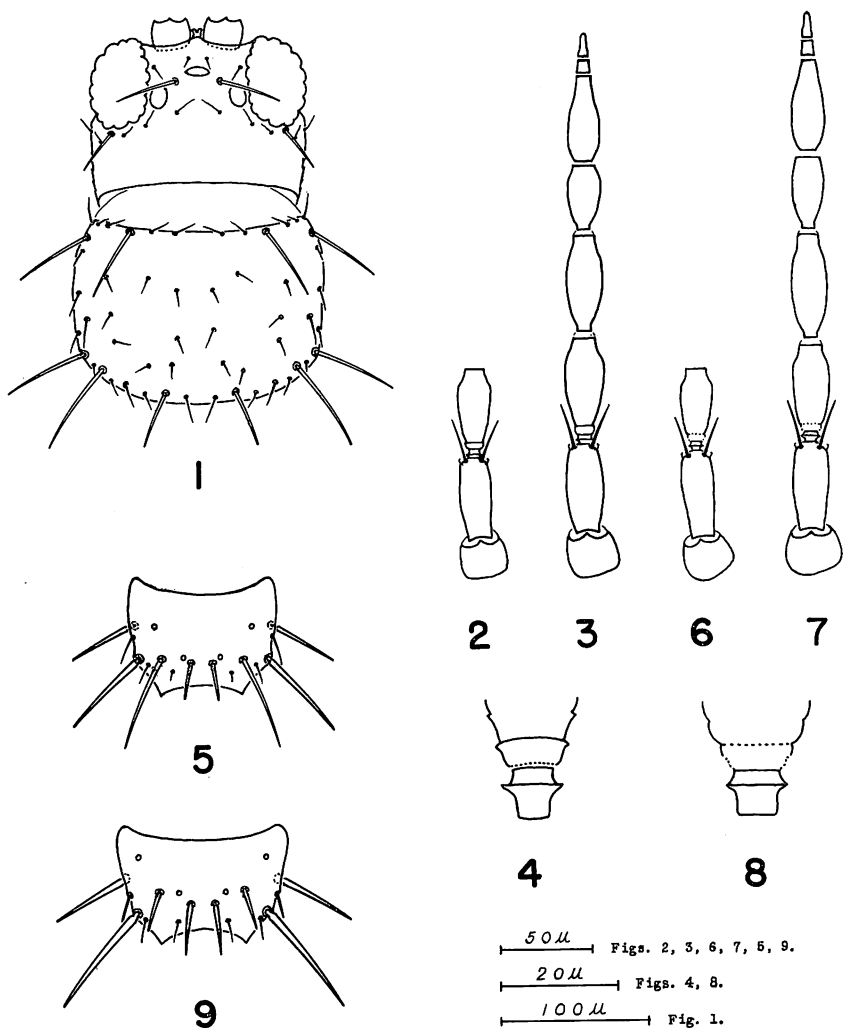


FIG. 1-5. *Frankliniella invasor*, n. sp.: 1, head and prothorax, ♀ paratype (4830), striae on either head or prothorax are not shown; 2, antenna I-III, right, ♂ allotype; 3, antenna I-VIII, right, ♀ paratype (4763); 4, antenna III pedicel, left, ♀ paratype (4825a); 5, tergite IX, ♂ paratype (4675).

FIG. 6-9. *Frankliniella gardeniae* Moulton: 6, antenna I-III, right, ♂ (45-3805); 7, antenna I-VIII, right, ♀ (45-3805); 8, antenna III pedicel, right, ♀ (45-3805); 9, tergite IX, ♂ (45-3805). Note: In fig. 2, 3, 6 and 7, striae, microtrichia, sense cones, and all setae except apical pair of II are not shown. (del. K. S.)

extreme tip of V (weak or often absent); VI-VIII dark grayish brown; legs uniformly yellow; wing pale yellow; ocellar crescent reddish brown; major setae dark grayish brown. Striae on occiput, pronotum, mesonotum, metascutum, abdomen narrowly-spaced and shallow.

Body 1520 (range among 20 paratypes: 1210-1600) (measurements in μ ; for length unless otherwise stated). Head (Fig. 1) 113 (95-118) (inclusive of interantennal carina), w. (= width) 145 (135-150), cheek narrower basally and weakly arched; eye 65, w. 39, interval between eyes 67; ocellar triangle 33, w. 58, ocellus 15 across; interocellar seta 40 (39-53), in front of posterior ocelli, 28 (20-30) apart from each other, dark; postocular seta iv (sequence from meson) 37 (26-40), dark, setae i-iii and v-vi and all other dorsal cephalic setae minute, yellow; mouth cone 187 (175-217) (distance from tip of interantennal carina to base of labial palpus), normal. Antenna (Fig. 3) 280 (248-295), about 2.5-2.7 times as long as head; length (width) of segments in holotype: 22 (28), 45 (20), 54 (19), 45 (18), 33 (15), 45 (18), 6 (8), 9 (6); II (Fig. 3) (40-48, w. 19-21, 2.0-2.3 times as long as wide), elongate, cylindrical without subbasal constriction, slightly produced anterodorsally and slightly extending over pedicel of III, a pair of slender setae at apex; produced foremargin difficult to discern unless the segment is properly oriented; III (48-59, w. 18-21, 2.6-2.9 times as long as wide), pedicel with saucer-like basal portion and bowl-like apical portion as Fig. 4, pedicel 12 (10-14), w. 11 (10-12); sense cones normal. Pronotum (Fig. 1) 120 (95-130), w. 163 (143-180), rather narrow; major setae all subequal, about $1/2$ pronotal length, anteromarginal 51 (49-67), 4 minor setae consistently between them, rarely reduced to 3 or increased to 5-6 but never reduced to 2, anteroangular 63 (53-70), posteromarginal ii 39 (34-55), i and iii-v minor but iv always somewhat thicker and longer than others, posteroangular i 68 (61-78), ii 65 (55-70). Pterothorax 170 (160-200), w. 225 (188-230); mesospinula nearly interrupted at middle, mesofurca small and metafurca large; metascutum with 2 small pores near hind margin; all legs normal, hind tibia 163 (135-174); forewing 670 (580-730), w. at middle 58 (50-63), number of setae: (22-27, 17-23, 14-17), their length at middle: (43-50, 35-42, 40-50). Abdomen 980 (790-1040), w. 250 (183-250) on IV, ctenidia and dorsal chaetotaxy normal for the genus; ovipositor 208 (190-230); comb on VIII short, 8 (8-13), shorter at middle and sometimes interrupted, 14 (12-15) teeth. Tergum IX 58 (50-65), X 58 (50-60); setae: IXi 79 (70-95), ii 85 (81-100), iii 93 (85-109), Xi 100 (91-115), ii 89 (85-103), caudal setae nearly subequal to each other but IXi shortest and Xi longest.

♂ (*Allotype*): Color and striation as ♀, exceptions: antenna II uniformly pale to yellow, grayish brown-wash weaker and less extensive on III-IV, extreme base of VI somewhat lighter; abdomen without any shading. Body 1090 (range among 18 paratypes: 950-1230); head 90 (88-100), w. 130 (113-138), interocellar seta 41 (38-48); postocular seta

iv 34 (25–36); mouth cone 170 (146–181). Antenna 245 (225–265); length (width) of segments in allotype: 20 (24), 44 (17), 48 (18), 43 (16), 29 (14), 39 (16), 5 (5), 8 (4); II (Fig. 2) (37–46, w. 15–17, 2.5–2.7 times as long as wide), conspicuously slenderer than ♀, anterodorsal production more pronounced than ♀; III (Fig. 2) (44–53, w. 17–19, 2.6–2.9 times as long as wide), pedicel (10–12, w. 10–10); VII–VIII often partly fused. Pronotum 98 (88–108), w. 138 (110–140); setae: anteromarginal 50 (35–58), anteroangular 51 (38–60), posteroangular i 52 (48–66), ii 48 (42–55), posteromarginal ii 34 (28–45); pterothorax 140 (125–165), w. 175 (138–180); hind tibia 128 (113–150); forewing 500 (420–610), w. at middle 43 (39–50). Abdomen 680 (580–780), w. on IV 140 (113–150); comb on VIII wanting except few minute teeth at sides; glandular area on sternites III–VII indistinct, discernible only on ventral mount under specially trained light, transversely oblong, (6–7, w. 28–38); genitalia 95 (85–100), w. 43 (40–45). Tergite IX (Fig. 5) 48 (40–50), X 43 (36–43); major setae blackish, chaetotaxy normal for the group, IXi short, 21 (18–24), dorsal seta i very long, 57 (45–66), 2.5–3.0 times as long as IXi, IXii–iii very thick and spur-like, ii 50 (43–55), iii 39 (32–46), all 3 accessory setae feeble and yellow, clasper 70 (60–79), very thick.

Holotype ♀ and Allotype ♂ (Bishop, Type No. 9619): Hawaii: Kahuku, Oahu, *Leucaena glauca*, flowers, 27-X-1966, K. Sakimura & Raymond Higa (Saki 4675). Paratypes (Sakimura, USNM, CAS): 21 ♀♀, 9 ♂♂, same as holotype; 5 ♀♀, 1 ♂ Kualapuu, Molokai, *L. glauca*, fl. 6-VI-1967, Sakimura (Saki 4763); 10 ♀♀, 10 ♂♂, Honolulu, Oahu, *Gardenia jasminoides*, fl. 26-III-1970, Sakimura (Saki 4825a); 11 ♀♀, 5 ♂♂, Kamiloloa, Molokai, *L. glauca*, fl., 23-VIII-1970, Sakimura (Saki 4830a). Puerto Rico: Paratypes: 3 ♀♀, 1 ♂ (CAS), Pueblo Viejo, *Mimosa glauca* (= *L. glauca*), fl., 7-XII-1943, L. J. McConnell (USNM 44-1265); 2 ♂♂ (USNM), Rio Piedras, no host data, 8-IX-1947, G. N. Wolcott (USNM 47-12970). Note: All the Puerto Rican specimens which are mostly damaged are not included in the aforementioned ranges; they are however all large in the range or somewhat larger.

Comparison: The new species belongs to the *tritici* group through its distinctly dilated antenna III pedicel and pale antenna V. Through a strongly elongated antenna II (Fig. 3, 7) which is rather unusual among members of the genus as well as the group, *invasor* resembles *gardeniae* Moulton from Mexico. On the other hand, however, both are abundantly distinctive from each other. Antenna II entirely and III partly grayish brown-washed in *invasor*, whereas both uniformly pale or yellow in *gardeniae*. Ocellar crescent is brownish in the former, and clear red in the latter. Cutaneous shading on abdomen is consistent in *invasor*, but completely absent in *gardeniae*. Antenna III pedicel is saucer-like with bowl-like apical portion atop in the former (Fig. 4), but ring-like with apical portion not particularly developed in the latter (Fig. 8). The number of minor

setae between pronotal anteromarginal setae is always 4 in *invasor*, but always 2 in *gardeniae*. Tergal comb on VIII is short and complete or sometimes interrupted in ♀ and practically absent in ♂ of the former, but long and complete in both ♀-♂ of the latter. Dorsal seta i on ♂ tergite IX is 2.5–3.0 times as long as IXi seta in *invasor* (Fig. 5), but decidedly shorter than IXi in *gardeniae* (Fig. 9). In a key to spp. of *Frankliniella* (Moulton, 1948: 91), *invasor* runs to couplet 132 (*cubensis* Hood and *gardeniae* Moulton). *F. cubensis* is separable from *invasor* through less slender antenna II, simple ring-like antenna III pedicel, and fairly long and complete tergal comb on VIII in ♀-♂. Through an affinity in the type of antenna III pedicel, *invasor* approaches *diversa* Hood from Panama. In *diversa*, however, antenna II is stout and laterally expanded at base, and postocular seta iv is undeveloped.

***Frankliniella gardeniae* Moulton (Fig. 6–9)**

Frankliniella gardeniae Moulton, 1948: 91, 107, Fig.

The original description is too brief to fully comprehend the species. The species is redescribed here from the unique holotype and 4 non-type specimens.

♀: Yellow body without cutaneous gray-shading on abdomen; antenna I pale, II–V yellow, IV distal 1/2 grayish brown, V weakly gray-washed along extreme tip, VI–VIII grayish brown; legs as body, wing yellow, ocellar crescent carmine red, major setae dark grayish brown. Striation on entire body same as *invasor*. Body 1480–1620 (all measurements in μ ; for length unless otherwise stated); head 113–115, w. (= width) 148–155; mouth cone 200–222, strongly tapered; antenna (Fig. 7) 290–292; II 45–49, w. 20–21, 2.3–2.5 times as long as wide, shape and modification same as *invasor*; III 53–56, w. 20–20, 2.7–2.8 times as long as wide, pedicel (Fig. 8) with simple ring-like dilation; interocellar seta 53–58, 27–30 apart from each other, in front of posterior ocelli; postocular seta iv 30–38. Pronotum 133–143, w. 180–198, setae: anteromarginal 65–75, only 2 minor setae between them, anteroangular 68–81, posteroangular i 75–88, ii 75–80, posteromarginal ii 38–43; pterothorax 205–213, w. 260–265, forewing 790–810, w. at middle 53–60, number of setae: 27–28, 21–22, 16–18; their length at middle: 51–53, 43–45, 48–55; hind tibia 165–193. Abdomen 970–1050, w. on IV 270–280; ovipositor 250–260; comb on VIII fairly long (13–15), complete, 12–13 teeth. Tergum IX 68–73, X 63–68; setae: IXi 90–93, ii 108–114, iii 110–113, Xi 117–127, ii 105–108.

♂: Color as ♀, pale to yellow, antenna IV basal 2/3 pale and the rest grayish brown, VI extreme base somewhat pale. Body 1240, head 100, w. 130, mouth cone 180; antenna 258; II (Fig. 6) 48, w. 18, 2.7 times as long as wide, slenderer than ♀; III (Fig. 6) 46, w. 18, 2.6 times as long as wide. Pronotum 105, w. 158; setae: anteromarginal 55, anteroangular 65, posteroangular i–ii 63–68, posteromarginal ii 38. Pterothorax 155,

w. 210; forewing 580, w. at middle 45; hind tibia 143. Abdomen 760, w. on IV 150; genitalia 107, w. 45; comb on VIII fairly long (12), complete, 13 teeth, differs from *invasor*; glandular area on sternites III-VII transversely oblong, 9-10, w. 30-43. Chaetotaxy on IX-X (Fig. 9) same as *invasor*, except dorsal seta i reduced; IXi 28, dorsal seta i 20, IXii 65, iii 45, clasper 86, all setae blackish and the last mentioned 3 setae very thick and spur-like.

Specimens examined: Holotype ♀ (USNM): Brownsville [interception] 13742, ex gardenia from Mexico, 25-I-1937, Singleton & Regan (USNM 37-2665) (a badly collapsed specimen); 2 ♀♀, 1 ♂ (CAS) and 1 ♀ (USNM), ideotypic but not paratypes, Cuernavaca, Morelos, Mexico, *Eucalyptus* sp., 21-XII-1944, N. L. H. Krauss (USNM 45-3805).

NOTES ON THE *Frankliniella* spp. IN HAWAII

Frankliniella williamsi Hood (= *flavens* Moulton) was first collected in 1927 in Honolulu, Oahu (Moulton, 1928: 108). Its preferred host is corn husks, within which it is transported from one place to another. The collections were recorded from Kauai, Oahu, and Hawaii, although it is very likely present on Lanai, Maui, and Molokai, too.

Frankliniella schultzei (Trybom) [(= *sulphurea* Schmutz, which is a yellow form of *schultzei*), according to the recent interpretation by Mound (1968: 39) and also see Sakimura (1969)], was first collected in 1942 at Poamoho, Oahu (Nishida, 1941). This is a general flower feeder with preference for legumes in dry areas. It was extremely abundant and common on every island until the early 1960's when it was partly replaced by *invasor*.

Frankliniella fusca (Hinds) was first collected in 1945 in Hilo, Hawaii (Sakimura, 1947). Narcissus flowers were found to be infested, but there has been no subsequent collection anywhere in Hawaii.

Frankliniella minuta (Moulton) was first collected in 1946 at Maile, Oahu (Sakimura, 1948). Its hosts are limited to composite flowers and it is common and abundant on *Verbesina encelioides* but records are still wanting from Maui and Hawaii.

Frankliniella occidentalis (Pergande), the western flower thrips of the Pacific Coastal States, was frequently intercepted over many years in Hawaii on imported vegetables and flowers, however, the first records of its establishment in the state were not made until 1966, when it was collected at Waimea, Kauai and Kula, Maui (Nakao, 1967). Subsequently, in searches so far made in my collection, the earliest specimens date back to July 1955 from Waimea, Kauai (Saki Acc. No. 3807); from Oahu and Maui, specimens date from 1958 (Acc. No. 4081, 4086) and from Lanai, 1961 (Acc. No. 4128). The species was also collected recently from

Hawaii, but records are still wanting from Molokai. We had long wondered, prior to the 1966 records, why this thrips had not become established in Hawaii, but the above records clearly suggest that it was probably established since the 1940's or possibly earlier before the arrival of *schultzei*. This species is a general flower feeder with preference in Hawaii for carnation, rose, some legumes with pea-type flowers, and some composites. Although it is not extremely common, it sometimes becomes abundant under particular circumstances, but its presence could be masked by the overwhelming populations of *schultzei* and *invasor*. Both *occidentalis* and *fusca* are the proved vectors of the tomato spotted wilt virus on tomato, papaya, lettuce, pineapple, and some ornamental plants, but the Hawaiian yellow form of *schultzei* is a non-vector.

Frankliniella invasor n. sp. was first collected from Sept. to Dec. 1966 at Kahuku, Oahu, the type locality, as well as numerous other localities throughout Oahu, Lanai, and Molokai and more recently on Maui. It has not yet been collected on Kauai and Hawaii, but there is little doubt of its occurrence on those islands. This species is another general flower feeder with a strong preference for some legumes with mimosa-type flowers, particularly *Leucaena glauca*, as well as rose and mango. It was very common and abundant when first discovered, indicating that it may have been established for some years previously and it has maintained high populations ever since. This species and *schultzei* are currently the predominating thrips in dry lowland areas.

Frankliniella hemerocallis Crawford was first collected in Sept. 1969 in Honolulu (Acc. No. 4815a), and it is now fairly common on *Hemerocallis* (the day-lilies), which appears to be its specific host, in Honolulu. The establishment of this species in Hawaii appears to be recent. Its origin is believed to be Eurasia and it is also known in Japan. Since 1948, it had been collected several times in the eastern United States (O'Neill & Nakahara, 1970). This species is primarily a leaf feeder and thrives within a narrow space between equitant basal portions of leaves and causes severe feeding scars, which subsequently become visible on open leaves. It also feeds under the stipule and bract on flower stalks. Injuries to the mature bud and open flower are limited, but transient adults are occasionally seen within open flowers, which all shrivel at nightfall. Its feeding habits, as reported here, somewhat resembles those of the gladiolus thrips, except that the latter voraciously feeds on buds and open flowers. Previously, little was known on the bionomics of this species. This thrips may have been transported from one place to another in infested tubers.

KEY TO THE HAWAIIAN SPECIES OF *Frankliniella*

- 1. Yellow body with yellow legs.....2
- Dark brown body5

2. Antenna II slender, about 2.0–2.3 times as long as wide; major setae dark grayish brown.....*invasor* n. sp.
Antenna II stout, about 1.5–1.7 times as long as wide.....3
3. Major setae on body and wing yellow to light brown; abdomen without cutaneous gray shading.....*williamsi* Hood
Major setae on body and wing dark grayish brown; abdomen with cutaneous gray shading.....4
4. Interocellar seta between posterior ocelli and set narrowly apart from each other; tergal comb on VIII wanting.....
.....Yellow form of *schultzei* (Trybom)
Interocellar seta in front of posterior ocelli and set widely apart from each other; tergal comb on VIII complete and fairly long.
.....*occidentalis* (Pergande)
5. Mid and hind tibiae uniformly as dark brown as body.....6
All tibiae uniformly or partly yellow.....7
6. Foretibia somewhat yellowish; postocular setae i-ii minute, iii short; tergal comb on VIII complete and very long.....
.....*minuta* (Moulton)
Foretibia as dark brown as body; postocular setae i-iii short, iv long; tergal comb on VIII complete but shorter (not yet collected in Hawaii).....Dark form of *occidentalis* (Pergande)
7. Antenna IV-V as dark brown as VI; postocular setae i-ii minute, iii short; tergal comb on VIII wanting; metascutal pores present.....*fusca* (Hinds)
Antenna III-IV as yellow as foretarsus; postocular setae i-iii minute, iv short; tergal comb on VIII complete but very short; metascutal pores wanting.....*hemerocallis* Crawford

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